AP Chemistry

Practice Midterm Exam

Part I corresponds to **Chapter 9**

Part II corresponds to **Chapters 1 - 3**

Part III corresponds to **Chapters 4 - 5**

Part IV corresponds to **Chapters 6 - 8**

ANSWER KEY

Name KEY

I.

A. (6 points) The ΔH_{vap} of H_2O is 40.7 kJ/mol. Its vapor pressure at 10.0°C is 9.21 mm Hg. What is its vapor pressure at 30.0°C?

$t_1 = 10.0°C \quad P_1 = 9.21\ mm\ Hg$

$t_2 = 30.0°C \quad P_2 = ?$

$$\ln \frac{P_2}{9.21} = -\frac{40.7 \times 10^3}{8.31}\left(\frac{1}{303} - \frac{1}{283}\right)$$

$P_2 = 28.9\ mm\ Hg$ or $0.0379\ atm$

B. (10 points) Consider cyclohexane (MM = 84.10 g/mol). At 25.0 °C, the vapor pressure of cyclohexane is 100.0 mm Hg. 0.0500 grams of cyclohexane are placed in a 50.00 mL flask at 25.0 °C. How many grams of liquid cyclohexane are left in the evacuated flask after equilibrium is established at this temperature?

$$\frac{100.0\ mm\ Hg}{760} \times 0.0500 = \frac{m}{84.10} \times 0.0821 \times 298$$

$m = 0.0226\ g$

liq. cyclohexane $= 0.0500 - 0.0226$

$= 0.0274\ g$

0.0274 g

C. (5 points) Write the compound with the higher boiling points in the blanks provided.

C_2H_5OH	**1.** C_2H_5OH or C_4H_{10}
HF	**2.** HF or HCl
ICl	**3.** Br_2 or ICl
NaCl	**4.** NaCl or SCl_2
$C_{12}H_{26}$	**5.** C_3H_8 or $C_{12}H_{26}$

Name _____

D. (18 points) Answer the following questions referring to the phase diagram of Z given below. Write your answers on the blanks provided.

l+s — **1.** What phase(s) is/are present at point X?

30°C, 300 mm Hg — **2.** What is the triple point for Z?

No — **3.** Can the compound be liquefied at 120°C by increasing the pressure to 950 mm Hg? **(YES** or **NO)**

liquid — **4.** What phase(s) is/are present at 45°C and 730 mm Hg?

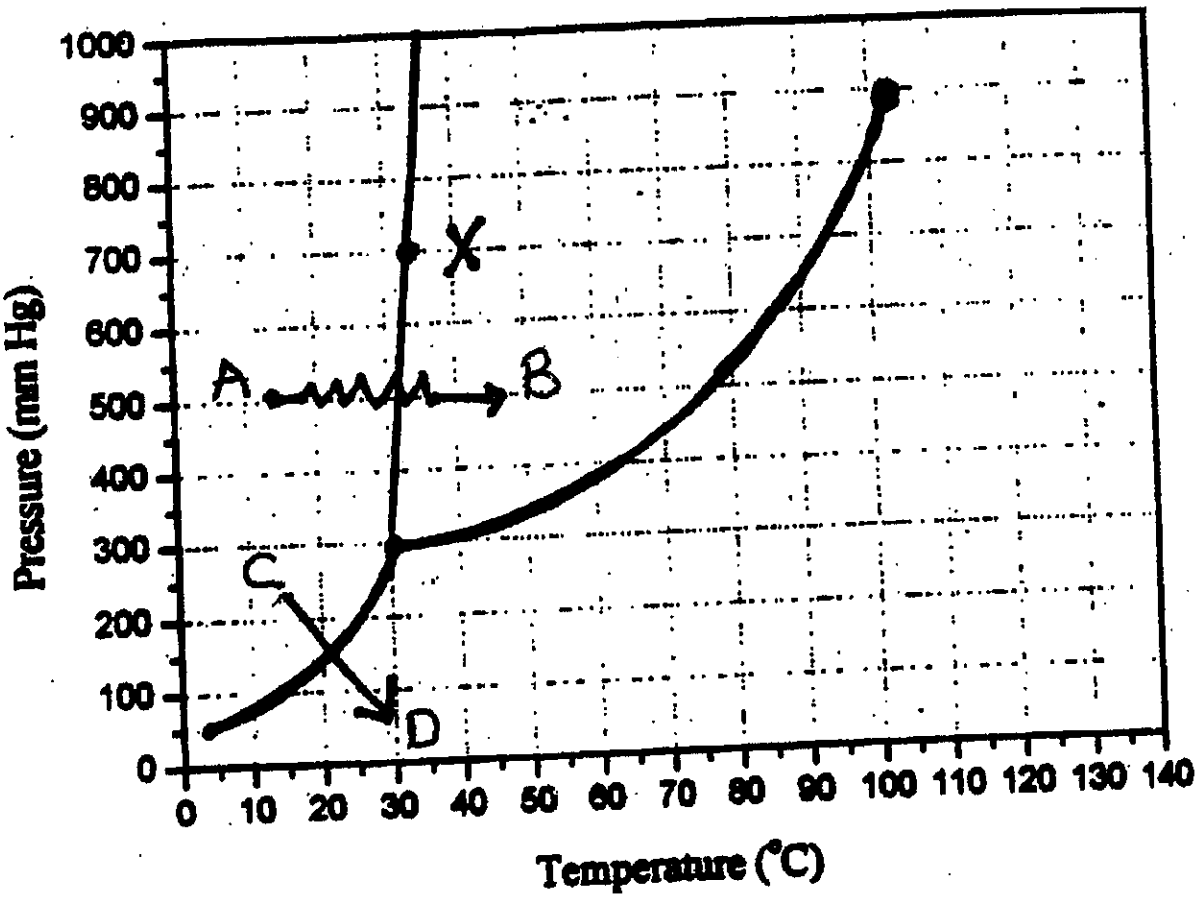
90°C - 100° C — **5.** What is the normal boiling point of Z?

350 mm Hg — **6.** At what pressure will the compound boil at 55°C?

melting — **7.** What process is indicated by going from A to B?

sublimation — **8.** What process is indicated by going from C to D?

solid — **9.** Which is the denser phase?



Name KEY

II.

A. (2 points) Answer the following questions on the blanks provided.

Co **1.** The transition metal in Group 9, period 4 is_____?

Cl-35 **2.** Which of the two isotopes of chlorine is more abundant: Cl-35 or Cl-37?

B. (4 points) Write the name of the element represented by the following symbol.

1. Ag silver
2. K potassium

C. (4 points) Write the symbol for the following elements.

1. magnesium Mg
2. copper Cu

D. (10 points) Answer the following questions on the blanks provided.

1. A $^{97}Mo^{3+}$ ion has 42 protons, 55 neutrons, and 39 electrons.
2. In a SO_4^{2-} ion there are 48 protons and 50 electrons.

E. (10 points) Supply the missing name or formula

1. Ca_3N_2 calcium nitride
2. iron(III) carbonate $Fe_2(CO_3)_3$
3. Se_2Cl_2 diselenium dichloride
4. calcium acetate $Ca(C_2H_3O_2)_2$
5. Cu_2S copper (I) sulfide

F. (5 points) How many bromine atoms are in 7.5 g of molecular bromine?

$$7.5\text{g } Br_2 \times \frac{1\text{mol } Br_2}{159.8\text{g}} \times \frac{6.022\times10^{23}}{1\text{mol } Br_2} \times \frac{2\text{atoms}}{1\text{molecule}}$$

5.7×10^{22} atoms of Br

Name KEY

G. (5 points) Calculate the average mass of one zinc atom in grams.

$$1\ Zn\ atom \times \frac{1\ mol\ Zn}{6.022 \times 10^{23}\ atoms} \times \frac{65.38\ g}{1\ mol\ Zn}$$

1.086×10^{-22} g Zn

H. (6 points) A "5 Liter" box of wine has the dimensions 10.5 in x 10.1 in x 3.75 in. Show that the plastic container inside such a box could hold 5.0 L of wine. (i.e. what is the volume of the box in L?) 1 in = 2.54 cm

$$\left(10.5\,in \times \frac{2.54\,cm}{1\,in}\right) \times \left(10.1\,in \times \frac{2.54\,cm}{1\,in}\right) \times \left(3.75\,in \times \frac{2.54\,cm}{1\,in}\right)$$

$$= 6516\,cm^3 \times \frac{1\,dm^3}{1000\,cm^3}$$

$$= 6.52\,L$$

6.52 L

I. (6 points) A solution is 12.0% of sodium hydroxide by mass and has a density of 1.131 g/mL. What volume of this solution (in mL) contains 3.50 g of sodium hydroxide?

$$3.50\,g\ NaOH \times \underbrace{\frac{100\,g\ soln}{12.0\,g\ NaOH}}_{29.2\,g\ soln} \times \frac{1\,mL}{1.131\,g} = 25.8\,mL$$

25.8 mL

J. (8 points) Consider the reaction: $3\ Br_2(\ell) + I_2(s) \rightarrow 2\ IBr_3(s)$

How many grams of $IBr_3(s)$ can be obtained from 8.00 g of Br_2 and an excess of I_2?

MM IBr_3 = 366.6

$$\text{mass of } IBr_3 = 8.00\,g\ Br_2 \times \frac{1\,mol\ Br_2}{159.8\,g} \times \frac{2\,mol\ IBr_3}{3\,mol\ Br_2} \times \frac{366.6\,g}{1\,mol\ IBr_3}$$

12.2 g IBr_3

Name KEY

K. (12 points) A gaseous mixture containing 4.0 mol of hydrogen gas and 3.0 mol of oxygen gas react to form steam according to the following reaction:

$$2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (g)$$

1. What is the limiting reagent? (The basis for your answer must be clearly shown.)

$$4.0\ mol\ H_2 \times \frac{2\ mol\ H_2O}{2\ mol\ H_2} = 4.0\ mol\ H_2O$$

$$3.0\ mol\ O_2 \times \frac{2\ mol\ H_2O}{1\ mol\ O_2} = 6.0\ mol\ H_2O$$

H_2 is limiting

2. What is the theoretical yield of steam in moles?

based on answer to the # 1

4.0 mol H_2O

3. Based on your answer in 2, how much steam is formed if the actual yield of the reaction is 80%?

$$80 = \frac{actual}{4.0} \times 100 = 3.2$$

3.2 mol or 57.7g

4. How many moles of the excess reactant remain unreacted based on your answer to part 2? Clearly state what that reactant is.

$$4.0\ mol\ H_2 \times \frac{1\ mol\ O_2}{2\ mol\ H_2} = 2.0\ mol\ O_2\ used$$

$3.0 - 2.0 = 1.0\ mol\ O_2$ is in excess

1.0 mol O_2

Name KEY

III.

A. (6 points) Write a net ionic equation for the reaction that occurs when solutions iron(II) nitrate and potassium phosphate are mixed? (Do not forget to include the physical states)

$3Fe^{2+}(aq) + 2PO_4^{3-}(aq) \rightarrow Fe_3(PO_4)_2(s)$

B. (6 points) Classify the following compounds as weak/strong acid (WA/SA) or bases (WB/SB) by circling your answer:

1. Sulfurous acid	(WA)	SA	WB	SB
2. Methyl amine (CH_3NH_2)	WA	SA	(WB)	SB
3. Hydrofluoric acid (HF(aq))	(WA)	SA	WB	SB

C. (6 points) If 17.5 mL of a HF(aq) solution react completely with (neutralize) 25.0 mL of 0.288 M $Ba(OH)_2$, calculate the molarity of the HF solution?

$$25.0\,mL\ Ba(OH)_2 \times \frac{0.288\,mol\ Ba(OH)_2}{1000\,mL\ Ba(OH)_2} \times \frac{2\,mol\ OH^-}{1\,mol\ Ba(OH)_2} \times \frac{1\,mol\ HF}{1\,mol\ OH^-}$$

$$M_{HF} = \frac{0.0144}{0.0175} = 0.823\,M$$

0.823M

D. (8 points) What is the volume of 1.222 M H_2SO_4 needed to completely react with (neutralize) 2.54 g of an aluminum hydroxide sample that is only 88% by mass pure?

MM $Al(OH)_3$ = 78.00

$$2.54\,g \times \frac{88}{100} = 2.24\,g\ Al(OH)_3$$

$$\#\ of\ mol\ of\ H_2SO_4 = 2.24\,g\ Al(OH)_3 \times \frac{1\,mol\ Al(OH)_3}{78.00\,g} \times \frac{3\,mol\ OH^-}{1\,mol\ Al(OH)_3} \times \frac{1\,mol\ H^+}{1\,mol\ OH^-} \times \frac{1\,mol\ H_2SO_4}{2\,mol\ H^+}$$

$$V = \frac{0.0430}{1.222} = 0.0352\,L$$

35.2mL

E. (4 points) A 5.00-L flask at 27°C contains methane gas at a pressure of 1.5 atm. How many moles of methane are in the flask?

$$1.5\,atm \times 5.00\,L = n \times 0.0821\,\frac{L \cdot atm}{K \cdot mol} \times 300\,K$$

0.30 mol

Name KEY

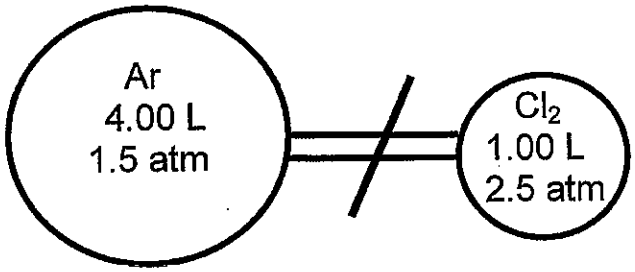
F. **(5 points)** An unknown gas X effuses 1.30 times faster than C_3H_8. What is the molar mass of gas X?

$$\frac{1}{1.30} = \sqrt{\frac{MM_x}{44.094}}$$

$$MM_x = 26.1\ g/mol$$

26.1 g/mol

G. **(6 points)** Consider two bulbs separated by a valve. Both bulbs are at the same temperature. Calculate the final pressure inside the system after the valve connecting the two bulbs is opened. Ignore the volume of the tube connecting the two bulbs.



$Ar: 4.00 \times 1.5 = 5.00 \times P_{Ar}$

$P_{Ar} = 1.2\ atm$

$Cl_2 = 2.5 \times 1.00 = 5.00\ P_{Cl_2}$

$P_{Cl_2} = 0.50\ atm$

$P_t = 1.7\ atm$

1.7 atm

H. **(5 points)** A sealed tube with He gas at 27°C and 1.5 atm is put into an oven where the temperature is 200°C. What is the final pressure of the helium gas in the tube at this temperature?

$$\frac{1.5}{P_2} = \frac{300}{473}$$

$$P_2 = 2.4\ atm$$

2.4 atm

Name _____

I. **(12 points)** Examine the following balanced half-reaction:

$H_2O + NO_2^-(aq) \rightarrow NO_3^-(aq) + 2H^+(aq) + 2e^-$

oxidation 1. Is this an oxidation or a reduction?

N 2. What *element* is oxidized or reduced?

Balance the following half-equation in acid (the answers will not be graded).

1 $MnO_4^-(aq)$ + 8 H^+ + 5 e^- → 1 $Mn^{2+}(aq)$ + 4 H_2O

The two reactions given above occur together. In the balanced equation for the overall reaction that occurs: (The balanced overall equation will not be graded, only the answers to questions 3 and 4.)

10 3. How many electrons are exchanged in the balanced equation?

MnO_4^- 4. What species was the oxidizing agent?

IV. **(81 points)** This part of the final corresponds to Exam III. It covers the material in Chapters 6, 7 and 8.

A. **(6 points)** In the blanks provided, answer the questions below.

Tc 1. What element has the electron configuration: [Kr] $5s^2 4d^5$?

Ge, Se 2. Give symbols for the atoms that have two unpaired 4p electrons?

9 3. How many electrons in a P atom have the ℓ quantum number equal to 1?

B. **(6 points)** Consider the atoms: Li, C, Rb, and Sn

C 1. Which is the smallest?

C 2. Which has the higest ionization energy?

Rb 3. Which has the lowest electronegativity?

C. **(3 points)** Consider the species: S, S^{2-}, Cl, and Cl^-

S^{2-} 1. Which is the largest?

D. **(3 points)** Consider the species: Na, Na^+, Mg, Mg^{2+}

Mg^{2+} 1. Which is the smallest?

Name KEY

E. (8 points) Draw a Lewis structure for ICl_4^- (the structure will not be graded)

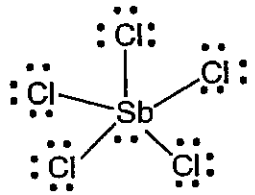
36 1. How many valence electrons are there?

octahedron 2. What is the electron pair geometry?

square planar 3. What is the molecular geometry of ICl_4^-?

90°, 180° 4. What is the predicted Cl-I-Cl angle?

F. (3 points) What is the formal charge on Sb in the following species -2



5 - 7 = - 2

5 - 2 - 5 = - 2

G. (4 points) Which of the following species is necessarily an exception to the octet?

NO_2^+ (NO) SO_2

H. (10 points) When 70.0 mL of 2.86 M NaOH at 22.0°C are neutralized by 70.0 mL of HCl also at 22.0°C in a coffee-cup calorimeter, the temperature of the final solution rises to 31.29°C. Assume that the specific heat of all solutions is 4.18 J/g°C, that the density of all solutions is 1.00 g/mL, and that the volumes are additive.

1. Calculate q for the reaction.

$q = 140.0 \times 4.18 \times (31.29 - 22.0)$

$= 5437\ J$

-5.44 kJ

2. Calculate q for one mole of NaOH.

$n_{NaOH} = 0.0700 \times 2.86 = 0.2002\ mol$

$1.000\ mol \times \frac{-5.44\ kJ}{0.2002\ mol} = -27.17\ kJ$

-27.2 kJ

Name KEY

I. **(12 points)** Consider the thermochemical equation shown below.

$$NH_4NO_3(s) \xrightarrow{H_2O} NH_4NO_3(aq) \qquad \Delta H = +25.7 \text{ kJ}$$

1. Calculate $q_{reaction}$ if 10.0 g of NH_4NO_3 (MM = 80.0) are dissolved in water.

$$10.0\text{ g } NH_4NO_3 \times \frac{1\text{ mol}}{80.0\text{ g}} \times \frac{25.7\text{ kJ}}{1\text{ mol } NH_4NO_3}$$

+3.21 kJ

2. Would the container feel "hotter" or "colder" as the dissolving occurs? **Circle one**

3. If the dissolving occurs in a coffee cup calorimeter containing 85.0 g of water initially at 23.0°C, what would be the final temperature? (Assume that the specific heat of the solution is the same as that of water, 4.18 J/g°C).

$$-3.21 \times 10^3 = 85.0 \times 4.18 \times (t_f - 23.0^\circ C)$$

ans. from #1 $t_f = 14.0^\circ C$ $\qquad \Delta t = -9.04^\circ C$

14.0°C

J. **(8 points)** Consider the following thermochemical data:

3/2 $2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O(g)$ $\Delta H° = -483.6$ kJ

G 1/2 $3\ O_2\ (g) \rightarrow 2\ O_3\ (g)$ $\Delta H° = +285.4$ kJ

Find ΔH_{rxn} for the reaction:

$$3\ H_2\ (g) + O_3\ (g) \rightarrow 3\ H_2O(g)$$

$O_3(g) \rightarrow 3/2\ O_2(g)$ $\qquad \Delta H_2° = \frac{-285.4}{2} = -142.7$ kJ

$3H_2(g) + \frac{3}{2}O_2(g) \rightarrow 3H_2O(g)$ $\qquad \Delta H_1° = \frac{3}{2}(-483.6)$

$= -725.4$ kJ

−868.1 kJ

Name KEY

K. (10 points) Using the data provided below answer the following questions.

Specific heat for liquid benzene	1.72 J/g·°C
$\Delta H_{vap}°$ for benzene	30.8 kJ/mol
Boiling point	80.0 °C
MM benzene	66.1 g/mol

1. Calculate ΔH for 75.0 g of benzene (g, 80.0 °C) → benzene (ℓ, 80.0 °C)

$$75.0\,g\ C_6H_6 \times \frac{1\,mol\ C_6H_6}{66.1\,g} \times \frac{-30.8\ kJ}{1\,mol\ C_6H_6} = -34.9\,kJ$$

-34.9 kJ

2. Calculate ΔH for 75.0 g benzene (ℓ, 80.0 °C) → benzene (ℓ, 24.0 °C)

$$\Delta H = 75.0\,g \times \frac{1.72\,J}{g \cdot °C} \quad (24.0 - 80.0)$$

-7224 J = -7.22 kJ

L. (8 points) Given

$2CuO(s) \rightarrow 2Cu(s) + O_2(g)$ $\Delta H° = +314.6$ kJ

1. What is the heat of formation of CuO?

$$\Delta H° = \Sigma \Delta H°_f(prod) - \Sigma \Delta H°_f(reac)$$

$$314.6 = (0+0) - 2 \times \Delta H°_f(CuO)$$

-157.3 kJ/mol

2. Calculate ΔH° for the formation of 13.6 g of CuO.

$$\Delta H° = 13.6\,g\,CuO \times \frac{1\,mol\ CuO}{79.55\,g} \times \frac{-157.3\,kJ}{1\,mol\,CuO} = -26.9\,kJ$$

$$\#\,of\,mol \times \frac{ans.\ in\ \#1}{1\,mol\ CuO}$$

-26.9 kJ